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AUTHOR Smith, Patricia L.; Wedman, John F.
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ABSTRACT

This study compared the effects of an elaborated unit of instruction and a hierarchical unit on students' online processing activities, efficiency of encoding new information, and facility in solving problems. Participants were six education graduate students rated as novices on the to-be-learned content--a unit on the principles of photography. Two versions of the unit were developed, a hierarchical version and a modified elaboration version. The elaborated version contained an epitome which introduced variables affecting picture quality and established the relationship between the variables. The results of analysis of the read-think-aloud protocols completed by each participant showed that participants responding to the hierarchical version performed many more elaborations than participants responding to the elaborated version. In addition, the hierarchical group performed more of the embedded practice items than the elaboration group. Finally, the average reading time of a targeted section for the hierarchical group was 8.3 minutes, compared to 6.0 minutes for the elaboration group. This reading time difference was expected, as the elaboration group had been exposed to an epitome which facilitated the encoding of new information within an already established cognitive structure of the basic relationships among variables. One table is included. (15 references) (EW)

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The Effects of Organization of Instruction on Cognitive Processing

Patricia L. Smith
University of Texas at Austin

John F. Wedman
University of Missouri

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The Effects of Organization of Instruction on Cognitive Processing

Traditional models of instructional design (Gagne & Briggs, 1979; Merrill, 1984) detail specifically how to design instructional strategies at the micro level. This is, they specify the sequence of events that should be included in instruction toward an individual objective. For instance, they suggest that when teaching toward a concept objective, the instruction should include a verbal statement of the definition of the concept, examples and nonexamples of the concept, and an opportunity for the learner to classify examples and nonexamples according to the concept's definition.

Yet, design models rarely suggest strategies for organizing instruction at the lesson, unit, or course level. To date, perhaps the most frequently used strategy for organizing instruction at these macro levels is the learning prerequisite sequence suggested by Gagne (1972). Several studies have examined the effectiveness of instruction designed using learning hierarchy prescriptions (e.g., Beeson, 1977; Eustace, 1969; Gagne, 1962; Headley, 1971; McCain, 1971; Okey, & Gagne, 1970). These studies typically compared instructional effectiveness before and after instruction using learning hierarchies and found hierarchically-arranged instruction to be generally superior to instruction designed using other means. However, such an approach may yield instruction that appears piecemeal, producing learners who have acquired individual skills and bits of knowledge, but who have failed to acquire the "big picture," a fully integrated schema of the content.

Instruction organized solely by prerequisites are generally unresponsive to the unique content structures of particular disciplines Therefore, such models may fail to take advantage of schemata that learners have already developed from encounters with traditional content structures in extant instructional materials.

Reigeluth is responsive to these criticisms of traditional design models by espousing the design of instruction based upon his Elaboration Theory of Instruction. The Elaboration Theory suggests that designers should begin the design of instruction by selecting an overriding organizational structure: conceptual, theoretical (based upon principles), or procedural. It further supports a method of sequencing instruction from the most simple and inclusive ideas in the content to the most complex and specific ideas. Reigeluth has borrowed the basis of this simple-to-complex pattern from Bruner's (1960) ideas of a spiral curriculum, from Ausubel's (1968) assimilation theory, and from Norman's (1973) concept of web learning.

The Elaboration Theory predicts that instruction designed on its principles will result in a) more fully integrated schemata, resulting in better retention and transfer at the application level; b) higher levels of learner motivation; and c) more efficient instruction based upon greater

learner control of selection and sequencing of content than materials developed using more traditional macro strategies (Reigeluth & Stein, 1983).

However, empirical studies have failed to fully support these predictions (Beukhof, 1986; Reigeluth & Stein). One possible reason for this failure is that researchers have not examined a full range of data sources when examining the differences between performances of learners encountering materials designed according to the Elaboration Theory versus more traditional approaches. Smith and Wedman (1986) proposed a number of additional data sources that might be sufficiently sensitive to examine some of Reigeluth's predictions.

The purpose of the current study was to compare the effects of an elaborated unit of instruction versus a hierarchical unit on students "on-line" processing activities, efficiency of encoding new information within the lesson, and facility in solving practice problems.

Method

Participants. Six university graduate students in the College of Education at a univeristy in the southwest who were rated as novice on the to-be-learned content (scoring less then 3 on a 15 item pretest) participated in this study. Students were randomly assigned to either a hierarchical or an elaborated version of the instruction (three students to each treatment).

Materials. Two versions, a hierarchical verson and a modified elaborated version, of a unit on Principles of Photography were developed. Both versions were developed to teach toward the objective "Learners will be given a setting (shutter speed and f-stop) that will yield a correct exposure and a clear image and a changing condition (lighting, motion, field of view, or film speed). They will be able to determine a correct setting, film speed, or other accommodations that will yield a correctly exposed, clear shot under the changed condition."

The elaborated version consisted of 105 pages, the hierarchical version, 80 pages. The content that was indicated in an instructional analysis to be prerequisite to learning the terminal objective was present in both treatments. Both sets of materials contained sequences of information presentation, practice items, and feedback.

The elaborated version contained an epitome, which introduced the variables (e.g., amount and duration of exposure) that affect picture quality and the relationship of these variables within an analogy. The epitome required the students to make non-numerical predictions about the relationships of these variables within specific contexts. The second part of the elaborated version introduced the numeric values associated with the previously-introduced variables and the numeric relationships between these variables. It also included synthesizers that tied each section of the second part of the unit to the epitome. The elaborated unit did not include the following aspects of elaborated instruction: summarizers,

cognitive-strategy activators, and explicit invitations to exercise learner-control.

The hierarchical version introduced each principle of creating quality photographs (e.g., correct exposure, clarity, etc.) and its related concepts in a sequence indicated by an instructional analysis. A 15-item pretest that contained near transfer items was administered to all participants. In addition, 70 embedded practice items were constructed to evaluate within-instruction learning (seven in the targeted section of instruction).

Procedure. Participants were introduced to the study and agreed to participate. Although they had been previously screened to ascertain that they were essentially novices in the content, they all completed a pretest. They were then trained and allowed to practice a read-think-aloud procedure in which they read the content aloud and attempted to make oral any thought processes that occured as they interacted with the materials.

After the experimenter was satisfied that the participant could use the procedure, the participant was presented with the first part of the materials, the tape recorder was started, and the student began to read and interact with the materials aloud. If the participant began to be silent, (s)he was prompted "what are you thinking /reading now?" After the student completed Part 1 (approximately 30-60 minutes), (s)he was given a 15-minute break. After the break, the student was reminded to "read and think aloud" and the tape recorder was started again. A break followed Part 2 (approximately 30-45 minutes), then Part 3 was completed (30-45 minutes). Entire instructional time ranged from two to three hours. As a comparison of posttest performance was not of interest in this particular study, no posttest was given.

Scoring. The read-think-aloud protocols were transcribed. Due to the volume of the data, only one section of these protocols was analyzed in this study. The researchers predicted that the difference in the effects of the two treatments would be greatest at the point in which the learners were required to manipulate a number of variables mentally at one time. Therefore, the segment of instruction that included the information presentation, practice, and related feedback on determining equivalent exposures was selected for this initial analysis.

First the protocols were examined for patterns of responses in the following areas: generation of examples, inferences, comparisons, analogies, mnemonics, paraphrases, misconceptions and their rectifications, summarization/review/rehearsal, self-monitoring, rereading, imaging, and questioning. Frequencies and durations of the above activities and their location within the materials were noted. During the analysis of these protocols the following categories of elaboration emerged: confusion, question, repeat/reread, paraphrase, elaborated paraphrase, retrieve concept definition, retrieve rule, summary, prediction, rule expansion/ application, tie to prior knowledge, example.

Time for encoding the new information presented in the targeted section and total learning time for the package were recorded. In addition, the number

of correct responses to the practice questions in the targeted section was calculated.

Results

Elaborations. Table 1 summarizes the frequencies of processing types for the hierarchical and elaboration groups.

Insert Table 1 about here.

As can be noted from the above Table participants responding to the hierarchical version performed many more elaborations than participants responding to the elaborated version.

Practice item performance. Of the 7 embedded items the average performance of the hierarchical group was 5.3, of the elaboration group was 4.3.

Time (facility) encoding. The average reading time of the targeted section for the hierarchical group was 8.3 minutes, of the elaboration group was 6.0.

Discussion and Conclusions

Of greatest interest in this set of data are the elaborations and the encoding times. The differences between number and type of elaborations bears further investigation. It may be that as participants in the hierarchical group had not had a cognitive structure built through an epitome (as the elaboration group may have) they needed to make a greater number of elaborations to build this schema.

The differences in encoding time for this section were as predicted. It was conjectured that learners that had been exposed to the epitome would be more facile in encoding new information because they would already have a cognitive structure of the basic relationships among variables into which the more detailed information could "hook." Therefore, it was expected that the elaboration group would take less time in encoding this information than the hierarchical group who would have to build the cognitive structure of relationships as they encoded the new information. The fairly substantial difference in encoding times seems to support this conjecture.

The time of encoding and number of elaborations seem to support each other and the conjectures as to the function of the elaboration in the instruction. However, conclusions from this study must be very tentative due

to the small number of participants. Future investigations may examine this relationship more closely.

In addition, future studies in this area may wish to examine participants' mental representations of the content by training them in a networking/pattern notes strategy and asking them to summarize the content that they have read in these forms. A comparison of the notes created by participants in elaborated and hierarchical groups might lead to some conclusions as to whether the prediction of more integrated schemata resulting from elaborated instruction can be substantiated. Other researchers may wish to examine the interactions between level of prior knowledge or processing style (such as wholist/serialist) and effectiveness of elaborated/hierarchical instruction. Certainly, future investigations should expand elaborated versions to include many levels of elaboration and all definitive characteristics of elaborated instruction.

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Table 1

Frequency of Elaborations in Specific Categories for Participants in Hierarchical Versus Elaboration Groups

Type of Elaboration	Hierarchical	Elaboration
Confusion	3	0
Question	5	1
Repeat/reread	1	2
Paraphrases	7	2
Elaborated paraphrases	2	1
Retrieve concept definition	1	0
Retrieve rule	1	0
Summary	1	2
Prediction	5	1
Rule expansion/application	3	0
Tie to prior knowledge	3	0
Example	0	1